## REMARKS/ARGUMENT

Subject matter from claims 10 and 22 has been incorporated into claim 1. Accordingly, claims 9, 10 and 22 have been canceled.

Claims 1-8 and 11-21 are currently pending.

In the Office Action dated May 17, 2006, the only rejection which encompassed both claim 10 and claim 22 was the rejection of claims 1, 4, 7-11, 16, 19, 21 and 22 under 35 U.S.C. § 102 as anticipated by U.S. patent 5,691,254 ("Sakamoto"). Because claim 1 has been amended to include limitations from both claims 10 and 22, all of the other prior art rejections have been rendered moot. Accordingly, Applicants respectfully request reconsideration and withdrawal of (1) the § 102 rejection based upon Shimatani; (2) the § 102 rejection based upon Nass; (3) the § 102 rejection based upon Wennemann; (4) the § 102 rejection based upon Boury; (5) the § 103 rejection based upon Nass or Wennemann in view of Kornbluth or Martin; (6) the § 103 rejection based upon Boury in view of Pinckney or Beall; (7) the § 103 rejection based upon Nass in view of Krause or Pourney; and (8) the § 103 rejection based upon Nass in view of Mewissen.

Regarding the remaining § 102 rejection based upon Sakamoto, the pending claims require the presence of 18-22% $Al_2O_3$. In sharp contrast, Sakamoto requires the presence of 4-8% $Al_2O_3$. (See, for example, col. 2, lines 44-46). For this reason alone the § 102 rejection is improper and should be withdrawn.

Moreover, Sakamoto actually teaches away from the high $Al_2O_3$ concentrations required by the claimed invention. Specifically, Sakamoto states that if more than 8% Sakamoto $Al_2O_3$ is present, glassflow is unacceptably deteriorated. (Col. 2, lines 44-46).

Thus, Sakamoto cannot teach or suggest the present invention which requires more than 8% $Al_2O_3$, let alone the required 18-22% $Al_2O_3$.

For all of the above reasons, Applicants respectfully request reconsideration and withdrawal of all pending prior art rejections.

The Office Action also rejected claim 22 under 35 U.S.C. § 112, second paragraph, as being indefinite because L*, a* and b* are undefined. In view of the following comments, Applicants respectfully request reconsideration and withdrawal of this rejection.

As noted at page 9 of the present specification, L*, a* and b* are well-known colorimetric coordinates in the CIELAB scale discussed in the 1986 reference cited on that page. That these colorimetric coordinates are well-known is further evidenced by the two Hunter Lab application notes (attached at Tabs A and B) which were obtained from the Internet as well as the ASTM standard attached at Tab C, particularly page 7 of this reference. Given that L*, a* and b* are well-known colorimetric coordinates in the CIELAB scale, Applicants respectfully submit that one skilled in the art would understand the meaning of L*, a* and b* in the present claims, meaning that these terms are definite. Accordingly, Applicants respectfully request reconsideration and withdrawal of the rejection under 35 U.S.C. § 112.

Applicants believe that the present application is in condition for allowance. Prompt and favorable consideration is earnestly solicited.

Respectfully submitted,

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APPLICATIONS NOTE

HunterLab

The Color Management Company

*Insight on Color* February, 2001, Vol. 13, No. 2

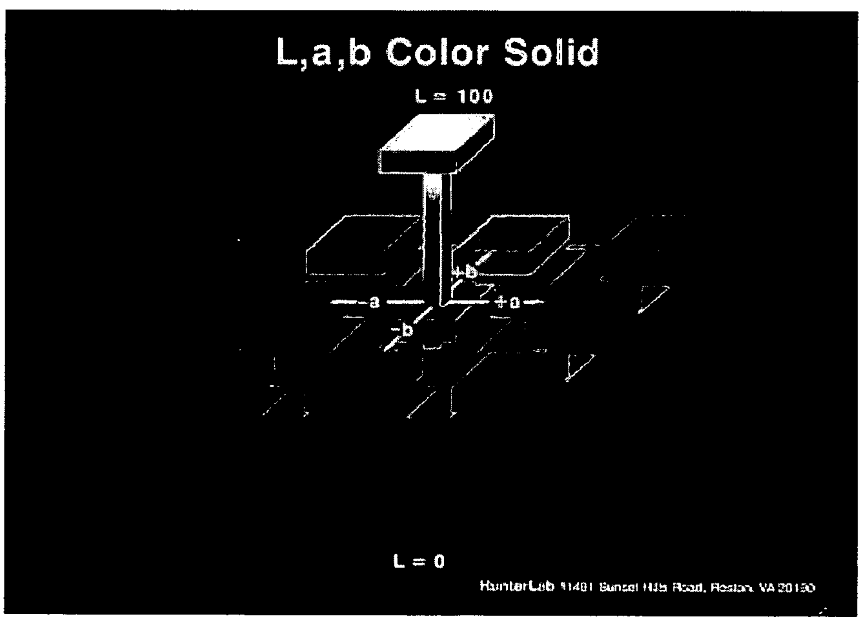
# Hunter L, a, b Versus CIE 1976 L*a*b*

## How Do They Compare?

Hunter L, a, b and CIE 1976 L*a*b* (CIELAB) are both color scales based on the Opponent-Colors Theory, which assumes that the receptors in the human eye perceive color as the following pairs of opposites:

- Light-dark
- Red-green
- Yellow-blue.

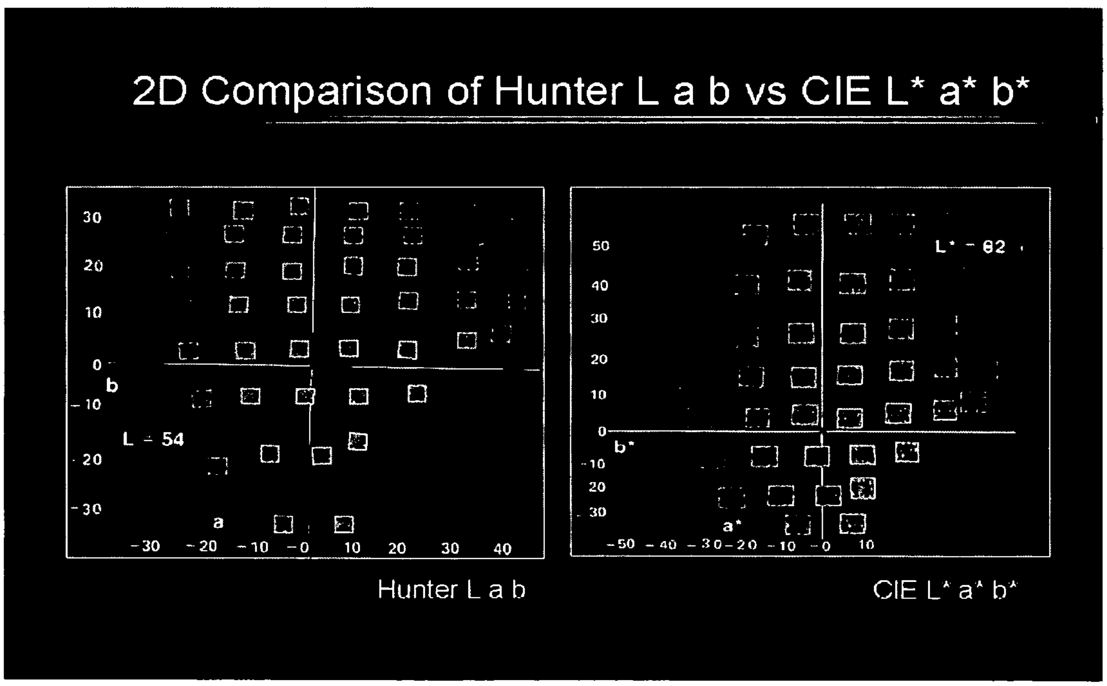
The L value for each scale therefore indicates the level of light or dark, the a value redness or greenness, and the b value yellowness or blueness. All three values are required to completely describe an object's color. A three-dimensional representation of L, a, b color space is shown below.



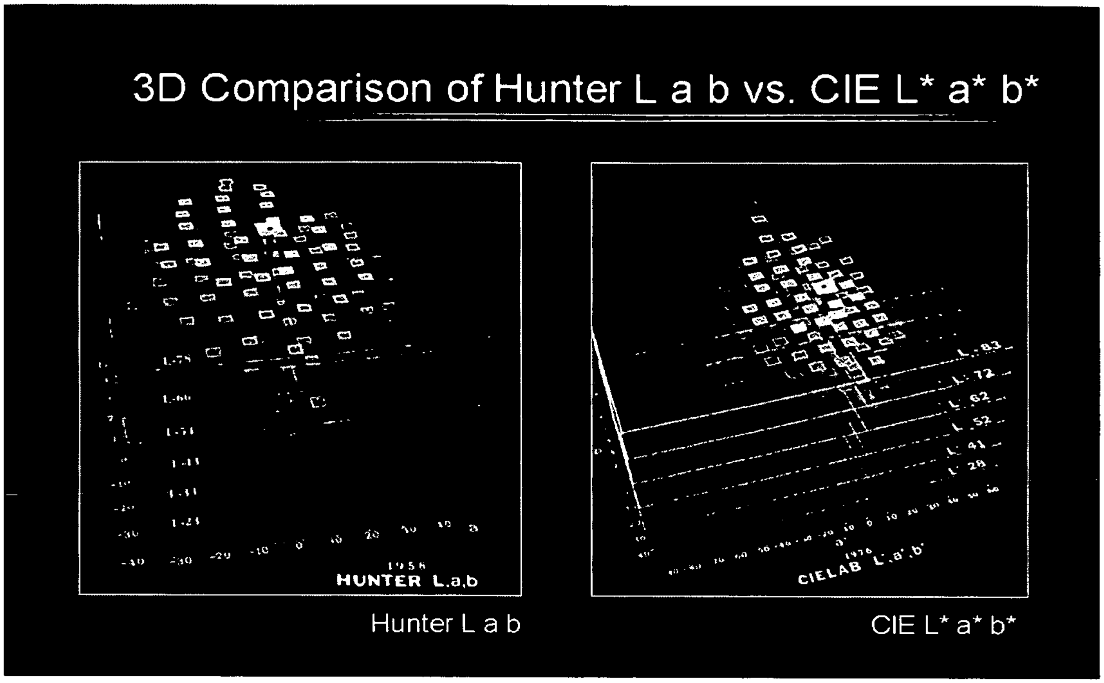
Both the Hunter L, a, b scale and the CIELAB scale are visually meaningful; the three values can be easily understood and translated into color. They are, however, calculated differently. The formulas for Hunter L, a, and b are square roots using CIE XYZ, whereas CIELAB is calculated using cube roots of XYZ. See the July 1-15, 1996 and August 1-15, 1996 *Applications Notes* for the formulas and more specific information about the two scales.

## Which Scale Should I Use?

So, which scale is best for you to use? Well, the CIE recommended the CIE 1976 L*a*b* scale in 1976 (Supplement No. 2 to CIE Publication No. 15, *Colorimetry*) as a improvement to the final version of Hunter L, a, b that was published in 1966, so if you wish to conform to this recommendation, use CIELAB, but as far as accuracy and descriptive value, neither Hunter L, a, b nor CIELAB clearly wins out as the better scale. Ideally, the scale used would be perfectly uniform throughout color space, meaning that a one unit difference between two colors would appear to be visually different by the same amount whether red, purple, orange, or blue. However, neither Hunter L, a, b nor CIELAB is perfectly uniform. The Hunter L, a, b scale contracts in the yellow region of color space and overexpands in the blue region. On the other hand, the CIELAB scale, although designed specifically to be more uniform, is still a bit over-expanded in the yellow region. This is a problem particularly when a sample's CIE Z value is less than one. The CIELAB scale generally gives better approximation to visual evaluation of color difference for very dark colors, though, because its equations are cube roots.




**The colored squares are more evenly spaced on the CIELAB charts above and on the next page.**




Specific recommendations are outlined in the table below.

| Use Hunter L, a, b when: | Use CIELAB when: |
|---|---|
| Pre-established specifications indicate Hunter L, a, b or measurements will be compared to ones made using the Hunter L, a, b scale. In this case, the scale you use is less important than being consistent in using the same scale for all the measurements being shared. (The food industry, for example, often specifies Hunter L, a, b, so most communication of results within this industry will be done using this scale.) | Pre-established specifications indicate CIELAB or measurements will be compared to ones made using the CIELAB scale. In this case, the scale you use is less important than being consistent in using the same scale for all the measurements being shared. |
| Historical color data was recorded in Hunter L, a, b. | Historical color data was recorded in CIELAB. |
| | You wish to conform to CIE's color scale recommendation. |
| | The best possible uniformity across color space is desired. |
| | You are measuring very dark colors. |

| Use Hunter L, a, b when: | Use CIELAB when: |
| --- | --- |
| | You are establishing a new measurement procedure, including indicating the color scale, and neither of the "Use Hunter L, a, b when" factors apply. |

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APPLICATIONS NOTE

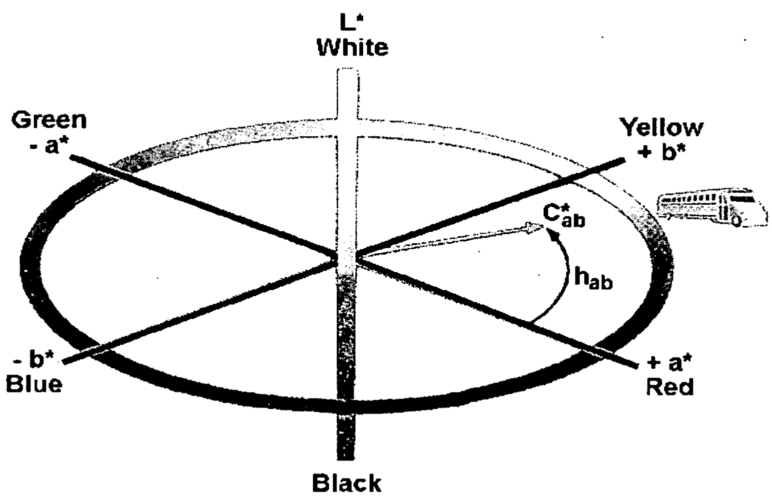
HunterLab

*Insight on Color* September 1-15, 1996, Vol. 8, No. 11

# CIE L*C*h Color Scale

## Background

The CIE L*C*h or CIELCh color scale is an approximately uniform scale with a polar color space. The CIELCh scale values are calculated from the CIELAB scale values. They are described in Section 4.2 of CIE Publication 15.2 (1986). The L*, lightness, value is the same in each scale. The C* value, chroma, and the h value, hue angle, are calculated from the a* and b* of the CIELAB scale. The CIELCh color space is diagrammed below.




The basic delta values for this scale are ΔL*, ΔC*, and ΔH*. They are the differences between the sample and standard in L*, C*, and h*. The total color difference, ΔE* is the same as the ΔE* in the CIELAB scale.

Another total color difference value often used with this color scale is $\Delta E_{cmc}$. $\Delta E_{cmc}$ and associated values will be discussed in a separate Applications Note. Please refer to it for further information.

## Conditions for Measurement

**Instrumental:** Any HunterLab color measurement instrument

**Illuminant:** Any

**Standard Observer Function:** 2 or 10 degree

**Transmission and/or Reflectance:** Either.

## Formulas

If $X/X_n$, $Y/Y_n$, and $Z/Z_n$ are all greater than 0.008856, then use the following equation for L*:

$$L^* = 116\sqrt[3]{\frac{Y}{Y_n}} - 16$$

If any of $X/X_n$, $Y/Y_n$, or $Z/Z_n$ is equal to or less than 0.008856, then use this equation for L*:

$$L^* = 903.3\left(\frac{Y}{Y_n}\right)$$

where

$X$, $Y$, and $Z$ are the CIE Tristimulus Values.

$X_n$, $Y_n$, and $Z_n$ are the tristimulus values for the illuminant.

$Y_n$ is 100.00.

$X_n$ and $Z_n$ are listed in the tables below.

**CIE 2 Degree Standard Observer**

| Illuminant | $X_n$ | $Z_n$ |
|---|---|---|
| A | 109.83 | 35.55 |
| C | 98.04 | 118.11 |
| $D_{65}$ | 95.02 | 108.82 |
| F2 | 98.09 | 67.53 |
| TL 4 | 101.40 | 65.90 |
| UL 3000 | 107.99 | 33.91 |
| $D_{50}$ | 96.38 | 82.45 |
| $D_{60}$ | 95.23 | 100.86 |
| $D_{75}$ | 94.96 | 122.53 |

**CIE 10 Degree Standard Observer**

| Illuminant | $X_n$ | $Z_n$ |
|---|---|---|
| A | 111.16 | 35.19 |
| C | 97.30 | 116.14 |
| $D_{65}$ | 94.83 | 107.38 |
| F2 | 102.13 | 69.37 |
| TL 4 | 103.82 | 66.90 |
| UL 3000 | 111.12 | 35.21 |
| $D_{50}$ | 96.72 | 81.45 |
| $D_{60}$ | 95.21 | 99.60 |
| $D_{75}$ | 94.45 | 120.70 |

$$C^* = \sqrt{a^{*2} + b^{*2}}$$

$$h = \arctan \frac{b^*}{a^*}$$

where

If $X/X_n$, $Y/Y_n$, and $Z/Z_n$ are all greater than 0.008856, then use:

$$a^* = 500\left(\sqrt[3]{\frac{X}{X_n}} - \sqrt[3]{\frac{Y}{Y_n}}\right)$$

$$b^* = 200\left(\sqrt[3]{\frac{Y}{Y_n}} - \sqrt[3]{\frac{Z}{Z_n}}\right)$$

If any of $X/X_n$, $Y/Y_n$, or $Z/Z_n$ is equal to or less than 0.008856, then use:

$$a^* = 500\left[f\left(\frac{X}{X_n}\right) - f\left(\frac{Y}{Y_n}\right)\right]$$

$$b^* = 200\left[f\left(\frac{Y}{Y_n}\right) - f\left(\frac{Z}{Z_n}\right)\right]$$

where

$$f\left(\frac{X}{X_n}\right) = \sqrt[3]{\frac{X}{X_n}} \qquad \text{when } X/X_n > 0.008856$$

$$f\left(\frac{X}{X_n}\right) = 7.87\left(\frac{X}{X_n}\right) + \frac{16}{116} \qquad \text{when } X/X_n < 0.008856$$

$$f\left(\frac{Y}{Y_n}\right) = \sqrt[3]{\frac{Y}{Y_n}} \qquad \text{when } Y/Y_n > 0.008856$$

$$f\left(\frac{Y}{Y_n}\right) = 7.87\left(\frac{Y}{Y_n}\right) + \frac{16}{116} \qquad \text{when } Y/Y_n < 0.008856$$

$$f\left(\frac{Z}{Z_n}\right) = \sqrt[3]{\frac{Z}{Z_n}} \qquad \text{when } Z/Z_n > 0.008856$$

$$f\left(\frac{Z}{Z_n}\right) = 7.87\left(\frac{Z}{Z_n}\right) + \frac{16}{116} \qquad \text{when } Z/Z_n < 0.008856$$

$$\Delta L^* = L^*_{sample} - L^*_{standard}$$

$$\Delta C^* = C^*_{sample} - C^*_{standard}$$

$$\Delta H^* = \sqrt{\Delta E^{*2} - \Delta L^{*2} - \Delta C^{*2}}$$ if $h°_{SMP} > h°_{STD}$, then $\Delta H^*$ is regarded as positive.

if $h°_{SMP} < h°_{STD}$, then $\Delta H^*$ is regarded as negative.

$$\Delta E^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

## Typical Applications

This color scale may be used for measurement of the color of any object whose color can be measured.

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# Standard Test Method for Computing the Colors of Objects by Using the CIE System[1]



This standard is issued under the fixed designation E 308; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.*

## INTRODUCTION

The CIE (Commission International de l'Éclairage or International Commission on Illumination) promulgates internationally recognized methods for color stimulus evaluation. The CIE system pr 'es standard data and computation methods. It utilizes spectrally defined color-matching functions, designated observers, and spectrally defined standard illuminants for computation of tristimulus values and chromaticity coordinates.

The original standard observer, adopted in 1931, is designated the "CIE 1931 Standard Observer," often referred to as the 2° observer because a 2° field of view was used in evaluating the color-response functions of the actual observers. Later it was found that the color-matching functions for this small field of view differed from those obtained with a larger field of view such as is commonly used in commerce. For this reason, color-matching functions obtained by use of a 10° field of view have also been recommended. Values for this larger field of view are designated the "CIE 1964 Supplementary Standard Observer," commonly referred to as the 10° observer.

## 1. Scope

1.1 This test method provides the values and practical computation procedures needed to obtain tristimulus values, designated $X$, $Y$, $Z$ and $X_{10}$, $Y_{10}$, $Z_{10}$ for the CIE 1931 and 1964 observers, respectively, from spectral reflectance or transmittance data for the specimen.

1.2 This test method includes procedures for conversion of results to color spaces that are part of the CIE system, such as CIELAB and CIELUV. Equations for comparing color differences in other color spaces are contained in Method D 2244.

1.3 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 2244 Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[2]

E 284 Terminology of Appearance[3]

2.2 *ANSI Standard:*

PH2.23 Lighting Conditions for Viewing Photographic Color Prints and Transparencies[4]

2.3 *CIE Standards:*

Publication CIE No. 15.2 (TC-1.3) Colorimetry[5]

Publication CIE No. 17 (E-1.1) International Lighting Vocabulary[5]

## 3. Terminology

3.1 *Definitions:*

3.1.1 *chromaticity*—the color quality of a color stimulus defined by its chromaticity coordinates (refer to CIE No. 17).

3.1.1.1 *chromaticity coordinates x, y, z*—the ratio of each tristimulus value (refer to 3.8) to the sum of the three values: $x = X/(X + Y + Z)$; $y = Y/(X + Y + Z)$, and $z = Z/(X + Y + Z)$.

3.1.1.2 *chromaticity diagram*—a plane diagram in rectangular coordinates formed by plotting two of the chromaticity coordinates, conventionally $y$ against $x$. (Figure 1 shows the CIE 1931 and 1964 chromaticity diagrams, including the locations of the spectrum locus from 380 to 760 nm and the purple boundary.)

3.1.2 *color (perceived)*—attribute of visual perception that can be described by color names such as white, gray, black, yellow, brown, vivid red, deep reddish purple, or by combination of such names.

3.1.3 *color (psychophysical)*—characteristics of a color stimulus (that is, light producing a sensation of color).

[1] This test method is under the jurisdiction of ASTM Committee E-12 on Appearance of Materials and is the direct responsibility of Subcommittee E12.02 on Spectrophotometry and Colorimetry.

Current edition approved Nov. 30, 1990. Published February 1991.

[2] *Annual Book of ASTM Standards*, Vol 06.01.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] Available from American National Standards Institute, 1430 Broadway, New York, NY 10018.

[5] Available from U.S. National Committee, CIE, National Institute of Standards and Technology, Gaithersburg, MD 20899.

TABLE 4 Relative Spectral Power Distributions $S(\lambda)$ of CIE Fluorescent Illuminants F2, F7, and F11

| λ (nm) | F2 | F7 | F11 |
|---|---|---|---|
| 380 | 1.18 | 2.56 | 0.91 |
| 385 | 1.48 | 3.18 | 0.63 |
| 390 | 1.84 | 3.84 | 0.46 |
| 395 | 2.15 | 4.53 | 0.37 |
| 400 | 3.44 | 6.15 | 1.29 |
| 405 | 15.69 | 19.37 | 12.68 |
| 410 | 3.85 | 7.37 | 1.59 |
| 415 | 3.74 | 7.05 | 1.79 |
| 420 | 4.19 | 7.71 | 2.46 |
| 425 | 4.62 | 8.41 | 3.38 |
| 430 | 5.06 | 9.15 | 4.49 |
| 435 | 34.98 | 44.14 | 33.94 |
| 440 | 11.81 | 17.52 | 12.13 |
| 445 | 6.27 | 11.35 | 6.95 |
| 450 | 6.63 | 12.00 | 7.19 |
| 455 | 6.93 | 12.58 | 7.12 |
| 460 | 7.19 | 13.08 | 6.72 |
| 465 | 7.40 | 13.45 | 6.13 |
| 470 | 7.54 | 13.71 | 5.46 |
| 475 | 7.62 | 13.88 | 4.79 |
| 480 | 7.65 | 13.95 | 5.66 |
| 485 | 7.62 | 13.93 | 14.29 |
| 490 | 7.62 | 13.82 | 14.96 |
| 495 | 7.45 | 13.64 | 8.97 |
| 500 | 7.28 | 13.43 | 4.72 |
| 505 | 7.15 | 13.25 | 2.33 |
| 510 | 7.05 | 13.08 | 1.47 |
| 515 | 7.04 | 12.93 | 1.10 |
| 520 | 7.16 | 12.78 | 0.89 |
| 525 | 7.47 | 12.60 | 0.83 |
| 530 | 8.04 | 12.44 | 1.18 |
| 535 | 8.88 | 12.33 | 4.90 |
| 540 | 10.01 | 12.26 | 39.59 |
| 545 | 24.88 | 29.52 | 72.84 |
| 550 | 16.64 | 17.05 | 32.61 |
| 555 | 14.59 | 12.44 | 7.52 |
| 560 | 16.16 | 12.58 | 2.83 |
| 565 | 17.56 | 12.72 | 1.96 |
| 570 | 18.62 | 12.83 | 1.67 |
| 575 | 21.47 | 15.46 | 4.43 |
| 580 | 22.79 | 16.75 | 11.28 |
| 585 | 19.29 | 12.83 | 14.76 |
| 590 | 18.66 | 12.67 | 12.73 |
| 595 | 17.73 | 12.45 | 9.74 |
| 600 | 16.54 | 12.19 | 7.33 |
| 605 | 15.21 | 11.89 | 9.72 |
| 610 | 13.80 | 11.60 | 55.27 |
| 615 | 12.36 | 11.35 | 42.58 |
| 620 | 10.95 | 11.12 | 13.18 |
| 625 | 9.65 | 10.95 | 13.16 |
| 630 | 8.40 | 10.76 | 12.26 |
| 635 | 7.32 | 10.42 | 5.11 |
| 640 | 6.31 | 10.11 | 2.07 |
| 645 | 5.43 | 10.04 | 2.34 |
| 650 | 4.68 | 10.02 | 3.58 |
| 655 | 4.02 | 10.11 | 3.01 |
| 660 | 3.45 | 9.87 | 2.48 |
| 665 | 2.96 | 8.65 | 2.14 |
| 670 | 2.55 | 7.27 | 1.54 |
| 675 | 2.19 | 6.44 | 1.33 |
| 680 | 1.89 | 5.83 | 1.46 |
| 685 | 1.64 | 5.41 | 1.94 |
| 690 | 1.53 | 5.04 | 2.00 |
| 695 | 1.27 | 4.57 | 1.20 |
| 700 | 1.10 | 4.12 | 1.35 |
| 705 | 0.99 | 3.77 | 4.10 |
| 710 | 0.88 | 3.46 | 5.58 |
| 715 | 0.76 | 3.08 | 2.51 |
| 720 | 0.68 | 2.73 | 0.57 |
| 725 | 0.61 | 2.47 | 0.27 |
| 730 | 0.56 | 2.25 | 0.23 |
| 735 | 0.54 | 2.06 | 0.21 |
| 740 | 0.51 | 1.90 | 0.24 |
| 745 | 0.47 | 1.75 | 0.24 |
| 750 | 0.47 | 1.62 | 0.20 |
| 755 | 0.43 | 1.54 | 0.24 |
| 760 | 0.46 | 1.45 | 0.32 |
| 765 | 0.47 | 1.32 | 0.26 |
| 770 | 0.40 | 1.17 | 0.16 |
| 775 | 0.33 | 0.99 | 0.12 |
| 780 | 0.27 | 0.81 | 0.09 |

7.4.1 *CIELAB or $L^*a^*b^*$*—This approximately uniform color space is produced by plotting in rectangular coordinates the quantities $L^*$, $a^*$, $b^*$ defined as follows:

$$L^* = 116(Y/Y_n)^{1/3} - 16$$

$$a^* = 500[(X/X_n)^{1/3} - (Y/Y_n)^{1/3}]$$

$$b^* = 200[(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}]$$

where:

$$X/X_n;\ Y/Y_n;\ Z/Z_n > 0.01.$$

The tristimulus values $X_n$, $Y_n$, $Z_n$ define the color of the normally white object-color stimulus. Usually, the white object-color stimulus is given by the spectral radiant power of one of the CIE standard illuminants, for example, *C*, $D_{65}$ or another of daylight quality, reflected into the observer's eye by the perfect reflecting diffuser. Under these conditions, $X_n$, $Y_n$, $Z_n$ are the tristimulus values of the standard illuminant with $Y_n$ equal to 100 obtained by use of the same method used to obtain *X*, *Y*, *Z*.

7.4.1.1 The CIE 1976 ($L^*a^*b^*$) space fails to approximate uniform color spacing when one or more of the ratios $X/X_n$, $Y/Y_n$, and $Z/Z_n$ is less than 0.01.

7.4.1.2 In calculating $L^*$, values of $Y/Y_n$ less than 0.01 may be included if the normal formula is used for values of $Y/Y_n$ greater than 0.008856, and the following modified formula is used for values of $Y/Y_n$ equal to or less than 0.008856:

$$L^* = 903.3(Y/Y_n) \quad Y/Y_n \leq 0.008856$$

7.4.1.3 In calculating $a^*$ and $b^*$, values of $X/X_n$, $Y/Y_n$, $Z/Z_n$ less than 0.01 may be included if the normal equations are replaced by the following modified equations for *all* calculations of $a^*$ and $b^*$:

$$a^* = 500[f(X/X_n) - f(Y/Y_n)]$$

$$b^* = 200[f(Y/Y) - f(Z/Z_n)]$$